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John Sauer

USGS Patuxent Wildlife Research Center

John Hadidian

The Humane Society of the United States

Sam Droege

USGS Patuxent Wildlife Research Center

Paul Handly

U.S. National Park Service

Carolyn Williams

Audubon Naturalist Society

See next page for additional authors

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Authors

John Sauer, John Hadidian, Sam Droege, Paul Handly, Carolyn Williams, Christopher Swarth, George Didden, and Jane Huff

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John R. Sauer
John Hadidian
Sam Droege
Paul Handly
Carolyn Williams
Chris Swarth
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Jane Huff

Abstract—Urban and suburban habitats often contain a variety of Neotropical migratory birds, but are poorly sampled by programs such as the North American Breeding Bird Survey. DC Birdscape was developed to inventory and monitor birds in Washington, DC. Birds were surveyed using a systematic sample of point counts during 1993-1995. Results indicate that species richness of Neotropical migratory birds varied among land-use categories, and that maximum species richness occurred in parkland habitats. Although DC Birdscape has provided relevant information on bird distribution and species richness, it is unclear whether the information is of sufficient management interest to support its continuation as a long-term monitoring program.

Neotropical migratory birds (NTMBS) tend to be associated with forests during the breeding season, leading many biologists to discount the importance of urban and suburban habitats for these species. However, information on population changes in NTMBS from urban parks has been influential in creating the perception of long-term declines in the species (Terborgh 1989), and the increasing extent of suburbia has caused urban habitats to appear near many areas that are surveyed by the North American Breeding Bird Survey (BBS; Peterjohn and Sauer 1993) that formerly were rural. The always-expanding suburban and urban centers provide experimental and management opportunities, because urban planners often have the opportunity to manipulate the extent and structure of woodlot fragmentation (Dawson and others 1993). As many people encounter birds

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John R. Sauer, USGS Patuxent Wildlife Research Center, 11510 American Holly Drive, Laurel, MD 20708. John Hadidian, The Humane Society of the United States, 2100 L Street N.W., Washington, DC 20037. Sam Droege, USGS Patuxent Wildlife Research Center, 11510 American Holly Drive, Laurel, MD 20708. Paul Handly, U.S. National Park Service, National Capital Region, 1100 Ohio Drive S.W., Washington, DC 20037. Carolyn Williams, Chris Swarth, George Didden, and Jane Huff, Audubon Naturalist Society, 8940 Jones Mill Road, Chevy Chase, MD 20815.

only in urban and suburban habitats, monitoring and managing birds in these areas will benefit the species and increase public awareness of management for NTMBS.

Washington, DC, contains a surprising number of urban parks and other habitats that support migrating and breeding NTMB species. Parks are of particular interest, and long-term data exist from Breeding Bird Censuses for some parks in Washington (Terborgh 1989), but how changes in these parks relate to regional bird population changes is unclear. To provide a regional context for the park data, a consortium of groups—including the Audubon Naturalist Society, the Biological Resources Division (then the U.S. Fish and Wildlife Service), and the National Park Service—worked together to design and implement a monitoring program for birds in Washington. Because the Washington region has a large concentration of amateur and professional ornithologists who have participated in Atlases and Christmas Bird Counts in the city, we felt that volunteer birders could be used as surveyors in the program. Here, we provide a brief summary of the project. A more extensive analysis is available in Hadidian and others (1997).

Methods

Field Methods

Bird sampling was conducted using single, 5-minute point counts on a systematic grid. Most of the sampling occurred in 1993, but additional counts were conducted in 1994 and 1995 to fill in gaps in coverage and to provide more intensive coverage in parks and other areas of particular interest. Here we present results from the initial 1993 survey only. The study area was metropolitan Washington, DC, on which a Geographic Information System (GIS) was used to define a grid with uniformly spaced intersections (nodes) at 500 m intervals (Hadidian and others 1997). Bird sampling was conducted at the 617 of these nodes that could be reached by observers.

To assist observers in locating points, field maps were created by using GIS to combine point locations with cartographic data. Maps were designed to show no more than nine points (the number of sample points that could be covered easily in one day), and to provide location information at a

reasonable scale. Experienced observers were assigned between one and ten map areas to be surveyed between 31 May and 30 June. Surveys were conducted between 0600 and 0930 on mornings when conditions permitted (no steady rain, and calm or low wind conditions). Time, weather conditions, and species and numbers of bird detected were recorded at each point.

Data Analysis

The initial intent of the program was to map bird species distributions within the city, to define associations between bird species distributions and land use in the city, and to provide information that could be used in conjunction with repeated surveys to assess bird population change.

To accomplish the first two goals, we used the GIS to associate the bird survey locations with coordinates on a map (to allow mapping) and with land-use at the locations. Seven land-use categories (Residential-low density, Residential moderate density, Residential-high density, Commercial, Public and Institutional, Parklands, and Industrial-Airport) were summarized from land-use classes developed by the District of Columbia Office of Planning and digitized for analysis (table 1). Survey locations were then overlaid onto the land-use categories for analysis.

In point count-based surveys, observers almost never count all of the birds at the points. To analyze the data, we

Table 1—Land use categories used in DC Birdscape project, with brief explanations about uses, estimated species richness of Neotropical migratory birds, and standard errors of the species richness estimates. Estimated species richness and its standard error also are provided for all habitats combined.

Category	Species richness	SE
Residential-low density (single family detached and semi-detached houses)	31	5.5
Residential-moderate density (row houses)	11	2.5
Residential-high density (multiple-unit housing, mid and high-rise apartments)	18	7.4
Commercial (low-high density shopping and service areas)	6	1.4
Public and institutional (land and facilities of federal and district government)	21	3.2
Parkland (district and federal parks, recreation centers, and open space)	39	3.7
Industrial-airport (industrial land and national airport)	9	2
Total	46	4.2

must assume that the proportion of birds missed at each point is consistent among points, an assumption that generally is not true (Barker and Sauer 1992). In surveys involving many observers, for example, it is likely that observer and habitat differences in detection rates of birds could invalidate comparisons based on numbers of birds counted (Barker and Sauer 1995). Consequently, we used relative abundance data only for map construction. Maps were made of distributions of birds using the count data from the sample points (Hadidian and others 1997).

Although comparisons of relative abundance from point counts can be biased by visibility differences, species richness can be estimated from count data using mark-recapture models (Burnham and Overton 1979). These statistical methods allow estimation of number of species present at each point (or land-use category) even if species are not encountered during sampling, and are generally applicable to the analysis of point count data (Nichols and Conroy 1996). We used the capture-recapture procedure to estimate species richness by land-use category for species categorized as Neotropical migratory species as defined in Peterjohn and Sauer (1993), then compared species richness among land-use categories, using a Chi-square test (Sauer and Williams 1989).

Results

Ninety-one species were observed at points sampled in 1993. The largest number of points were located in Parkland (171 points), while only 21 points were located in High-density residential areas. See Hadidian and others (1997) for a detailed analysis of species richness for a variety of species groups and habitats.

Species Richness of Neotropical Migratory Birds

The estimated total species richness of NTMBs in the Washington, DC, metropolitan area was 46 (± 4 SE) (table 1). The estimated species richness for all species was 115 (± 8 SE), closely matching the documented species total from anecdotal sources.

Estimated species richness of NTMBs differs greatly ($P < 0.001$) among land-use categories in Washington, ranging from 6 in Commercial areas to 39 in Parklands. In Hadidian and others (1997), we document other aspects of species richness, and assess the association between size of land-use category and species richness.

Relative Abundance Maps

Maps have been produced for a variety of species, and these maps provide the first quantitative information about relative abundance for the species within Washington, DC. They will be made available to urban planners and the public through publications, Internet home pages, and other outlets. See Hadidian and others (1997) for examples of relative abundance maps produced from DC Birdscape. Point maps of species distributions are available over the Internet (<http://www.mbr-pwrc.usgs.gov/dcbirds/dcbird.html>).

As expected, patterns of relative abundance for most species reflect the availability of habitat. For example, Parks and other forested areas contain Wood Thrush (*Hylocichla mustelina*), while other areas generally do not.

Discussion

Is DC Birdscape a Monitoring Program?

DC Birdscape originally was intended to provide a systematic sample of bird species' relative abundances and distributions throughout the metropolitan area. From these data, associations among land-use categories, other habitat features, and abundances provided information for land managers on possible consequences of land use changes on bird communities. The data also provided an extensive view of bird distributions within the region for public use. Most participants in the planning of the study believed that it would be repeated after several years, to allow for monitoring of changes, but no organization committed itself to planning future surveys.

Although DC Birdscape clearly has the potential to monitor population change, several conditions should be met before a decision can be made to repeat the survey.

1. It must be documented that the information is of use to managers. If information about bird population changes in the urban area is not likely to be used by urban planners and bird population biologists, then the program should not be repeated. Goals must be developed for the repeated survey, and support must be obtained from potential users of the data. Of course, this is an interactive process, and making land managers and planners aware of the existence of the data is an essential function of the organizers.

2. The efficiency of the survey to estimate population change must be evaluated. If the estimates of population change from the repeated survey are extremely imprecise, the data will be useless for management. Several methods exist to assess the efficiency of the survey. Replicate counts at the sample locations can be used to assess within-year variation in counts (Link and others 1994), or replication of a subset of points in a future year could be used to provide pilot information on population change. These evaluations should be conducted before any long-term program is implemented.

3. An administrative structure must be developed to support the survey. Biologists hate bureaucracies, which

generally stifle innovation and divert funds from operational programs. However, DC Birdscape has been greatly hampered because it lacks a coherent source of funding. Most of the work on the project has not been officially supported, leading to analyses not being completed on schedule. To continue the survey, a source must be identified to fund staff for organizing the fieldwork, collating the data, and conducting analyses.

How Could DC Birdscape Contribute to Large-Scale Monitoring Efforts?

If the survey provided estimates of population change for Washington, DC, the information would be useful in several contexts. The Washington region has a variety of land management agencies that monitor parks, military lands, and other areas. Most managers are interested in changes in bird populations on their lands. The GIS component of DC Birdscape provides explicit information about the association of points with land-use information. This information can be used to determine associations between changes in land use and changes in bird populations. Although these associations do not necessarily imply cause and effect relationships, managers can use them to determine post-hoc effects of changes in land use.

Although the area monitored by DC Birdscape is small relative to the extensive coverage provided by monitoring programs such as the BBS, the information from the more intensive, explicitly georeferenced program could provide valuable additional information. Information from the survey could be combined with the more extensive information by considering the area as a separate strata, although some technical issues need to be resolved in combining the indexes from the surveys.

Surveys such as DC Birdscape also play a role in bridging the gap between local studies, such as Breeding Bird Censuses (BBC; Johnston 1990) in individual woodlots, and large scale programs such as the BBS. The BBS often is criticized because it is large scale and landscape level, hence using the information to address local issues is difficult. Local surveys, such as the BBC, have only a local context that does not allow assessment of large-scale patterns of population change. DC Birdscape, with its local and regional components, could play a valuable role in reconciling patterns of population change in single sites with regional patterns of population change.